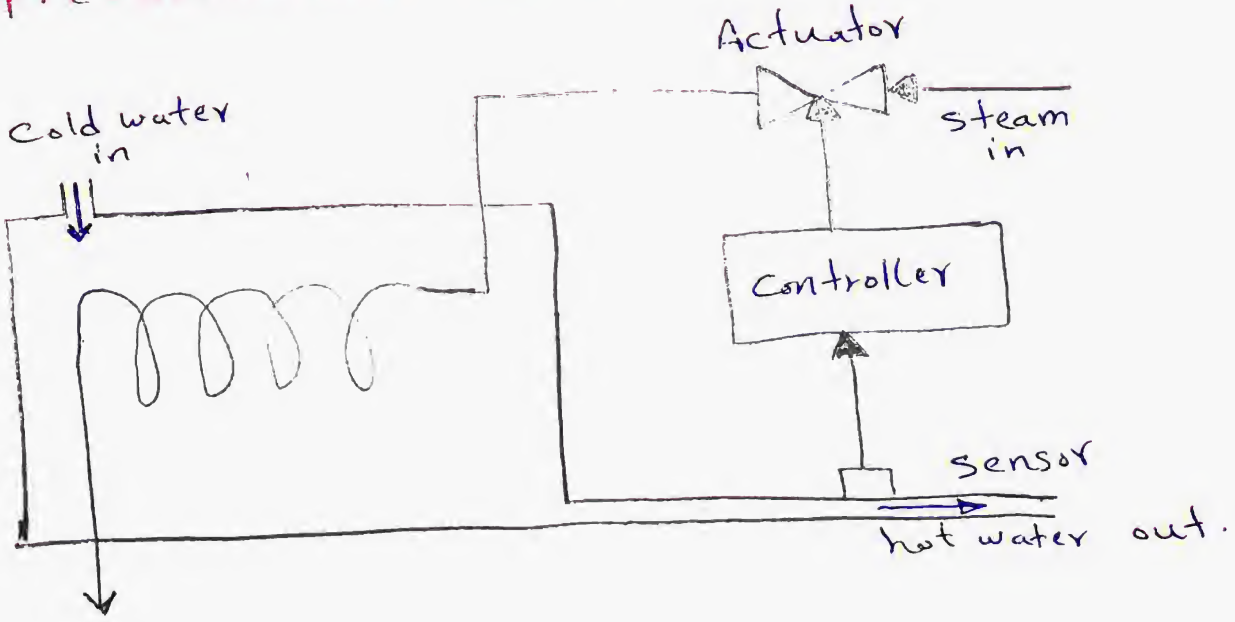
Industrial Control

Final 2016

Thanks to Mohamed, Seada & Amr Elshenawy For helping in solving 2nd question..

Final 2016

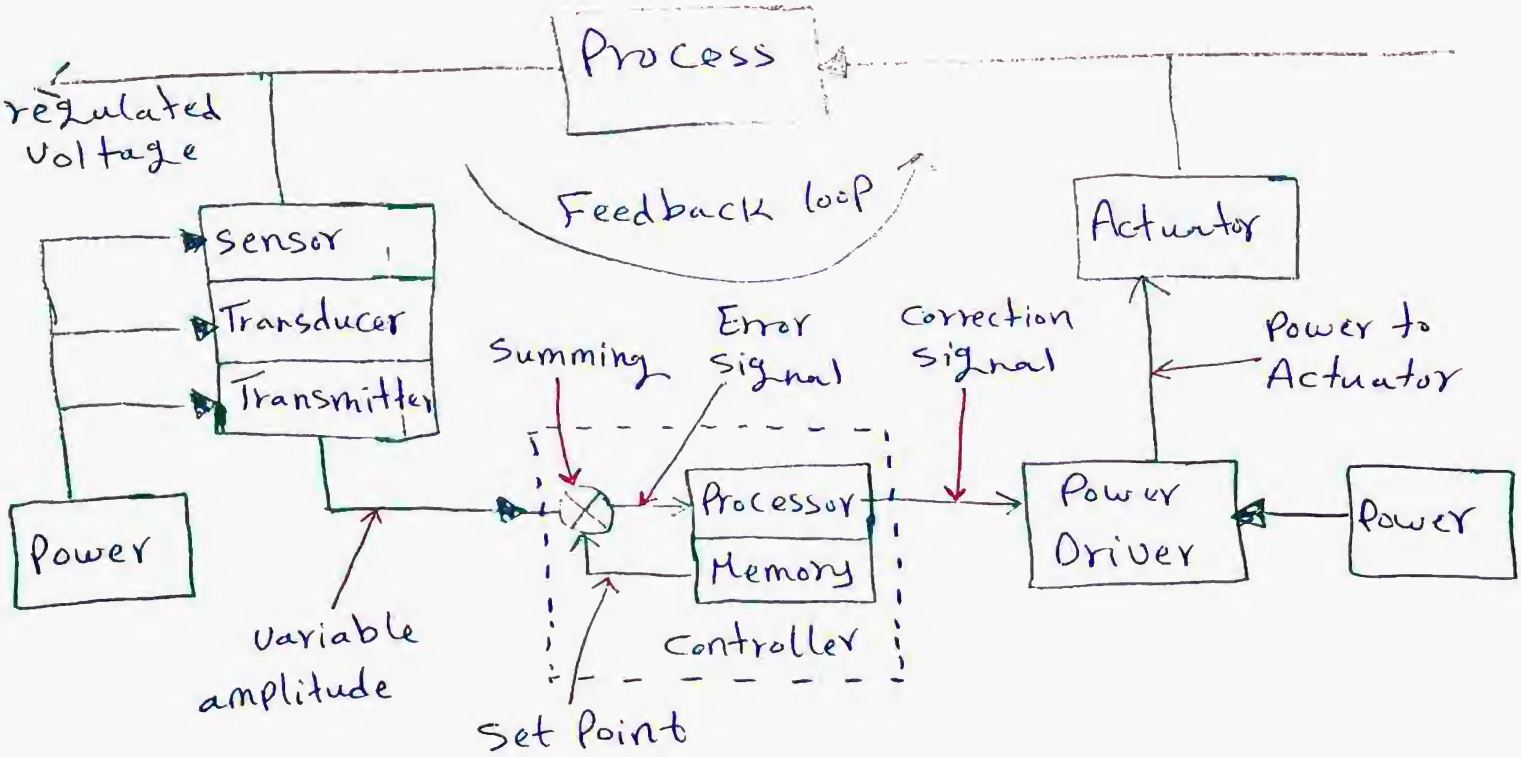
Q1: a) Explain with the aid of a block diagram how an automatic control of a heat exchanger process can be able to control and adjust the flow of steam to the heat exchanger to keep the temperature of the water at its pre-determined value.



→ sensor is attached to outlet pipe senses the temperature of water flowing. As the demand of hot water increases or decreases, change in water temp. is sensed & converted to electrical signal, amplified and sent to controller that evaluates signal and send correction signal to actuator which adjust the flow of steam to keep the temp. on its value.

Q.)

b) Explain how to construct a block diagram of elements that make up the feedback path in a process-control loop including most of well-known measuring elements such as sensor, transducer, transmitter, control element, power circuit. and its own power supply.



* memory & summing circuit to compare the set point to the sensed signal so that it can generate an error signal to control the actuator and input variable.

Q1.c) True or False

i) In Process control systems, a manipulated variable is defined as the output response or parameter to a process that is varied by a control signal from the processor to an actuator (False)

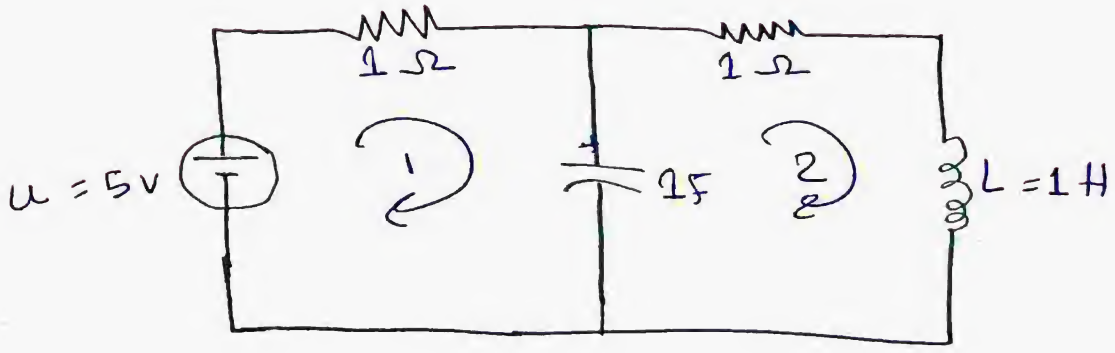
ii) The time delay systems are systems that based on receiving delayed controlled or measured signals Produced in most electro-mechanical systems which are essential in the operation of most Process control systems (Yes)

Q2:a

i) Derive linear time-invariant dynamic description of this network in the form:

$$\dot{x} = Ax + Bu \qquad y = Cx$$

ii) Draw simulink diagram for i .....



$$x_1(t) = V_c(t)$$

$$x_2(t) = i_L(t)$$

apply K.V.L in ② ②

$$V_c + i_L R + V_L = 0$$

$$V_c + i_L + L\frac{di_L}{dt} = 0$$

$$\frac{di_L}{dt} = -V_c - i_L$$

$$\dot{x}_2(t) = -x_1(t) - x_2(t) \longrightarrow a$$

apply KV.L at (1)

$$V_{in} = iR + V_c$$

$$u = i + V_c$$

$$u = i_c + i_L + V_c$$

$$u = C\frac{dV_c}{dt} + i_L + V_c$$

$$\frac{dV_c}{dt} = -V_c - i_L + u$$

$$i = i_c + i_L$$

$$i_c = C\frac{dV_c}{dt}$$

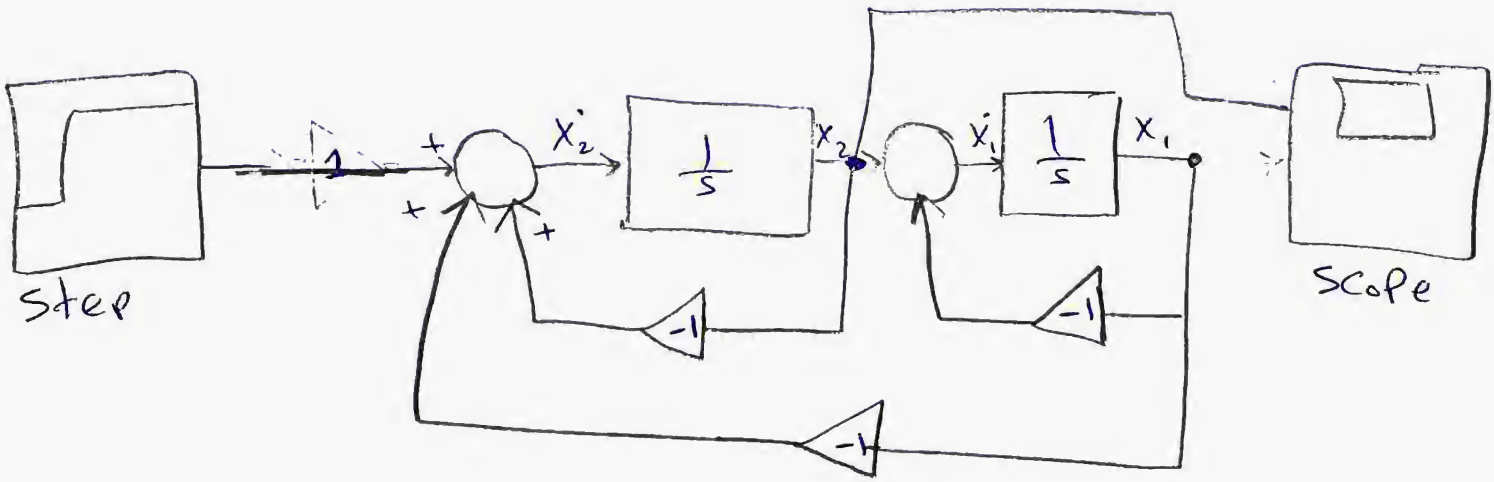
$$\dot{x}_1(t) = -x_1(t) - x_2(t) + u(t) \longrightarrow b$$

$$V_c = y(t) = x_1(t) \longrightarrow c$$

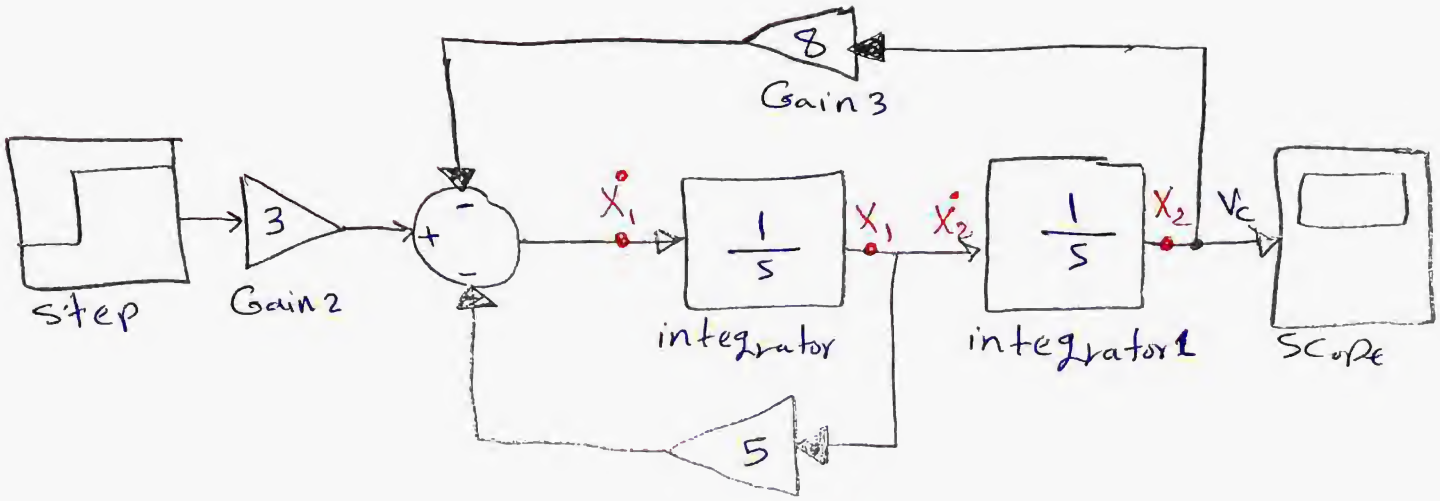
From a, b, c

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -1 & -1 \\ -1 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$$

$$y(t) = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$



Q2:b Consider this figure



a) write state space in the form

$$\dot{x} = Ax + Bu \qquad y = Cx$$

b) This system can be controlled or not?

$$V_c = X_2 \longrightarrow \boxed{y(t) = X_2(t)} \Rightarrow (1)$$

$$\boxed{\dot{X}_1 = -5X_1 - 8X_2 + 3u} \longrightarrow (2)$$

$$\boxed{\dot{X}_2 = X_1} \quad (3)$$

$$\dot{x}(t) = \begin{bmatrix} -5 & -8 \\ 1 & 0 \end{bmatrix} x(t) + \begin{bmatrix} 3 \\ 0 \end{bmatrix} u(t)$$

$$y(t) = \begin{bmatrix} 0 & 1 \end{bmatrix} x(t)$$

Controllability

$$M_c = \begin{bmatrix} B & AB \end{bmatrix}$$

$$= \begin{bmatrix} 3 & -15 \\ 0 & 3 \end{bmatrix}$$

$$|M_c| = 9 \neq 0 \rightarrow \text{Controllable}$$

Q2: c) Consider this equation

$$9u_1(t) = 3\dddot{z}(t) + 3\dot{z}(t) - 3z(t) + 6u_2(t) \longrightarrow *$$

$$y(t) = \dot{z}(t) + 3z(t) + 5u_2(t) \longrightarrow **$$

→ Draw simulink diagram

$$x_1 = z(t) \longrightarrow \dot{x}_1(t) = \dot{z}(t)$$

$$x_2 = \dot{z}(t) \longrightarrow \dot{x}_2(t) = \ddot{z}(t)$$

$$x_3 = \ddot{z}(t) \longrightarrow \dot{x}_3(t) = \dddot{z}(t)$$

$$\dot{x}_1 = x_2 \longrightarrow (1)$$

$$\dot{x}_2 = x_3 \longrightarrow (2)$$

in *

$$9u_1(t) = 3\dot{x}_3(t) + 3x_2(t) - 3x_1(t) + 6u_2(t)$$

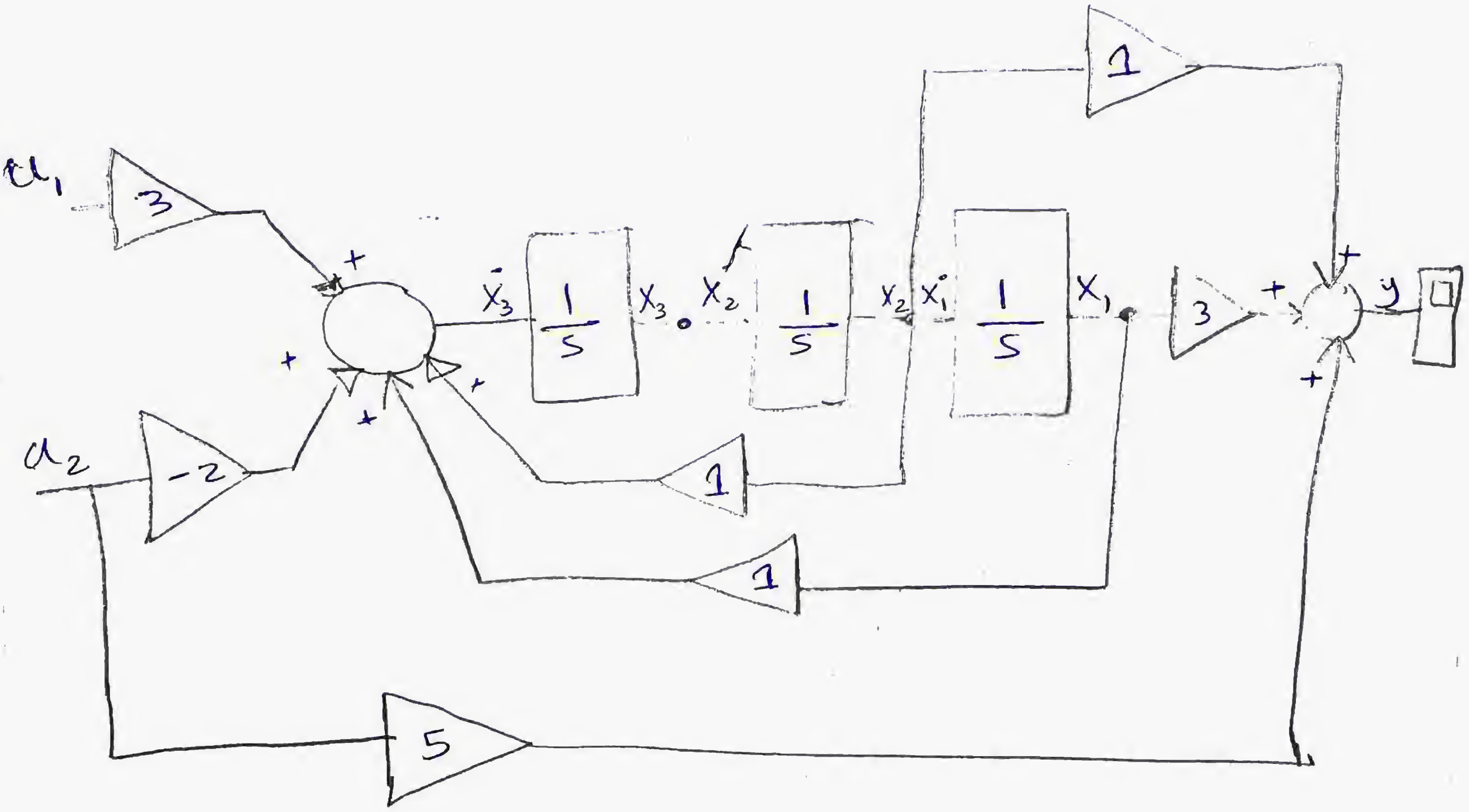
$$3u_1(t) = \dot{x}_3(t) + x_2(t) - x_1(t) + 2u_2(t)$$

$$\dot{x}_3(t) = x_1(t) + x_2(t) + 3u_1(t) - 2u_2(t) \longrightarrow a$$

$$y(t) = x_2(t) + 3x_1(t) + 5u_2(t) \longrightarrow b$$

$$\dot{x}(t) = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix} x(t) + \begin{bmatrix} 0 & 0 \\ 0 & 0 \\ 3 & -2 \end{bmatrix} u(t)$$

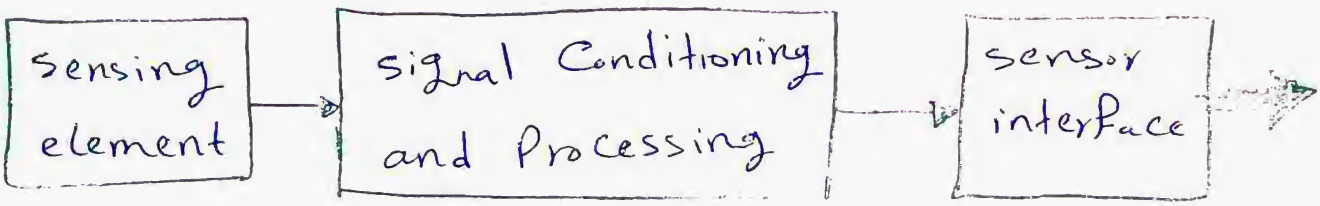
$$y(t) = \begin{bmatrix} 3 & 1 & 0 \end{bmatrix} x(t) + \begin{bmatrix} 0 & 5 \end{bmatrix} u(t)$$



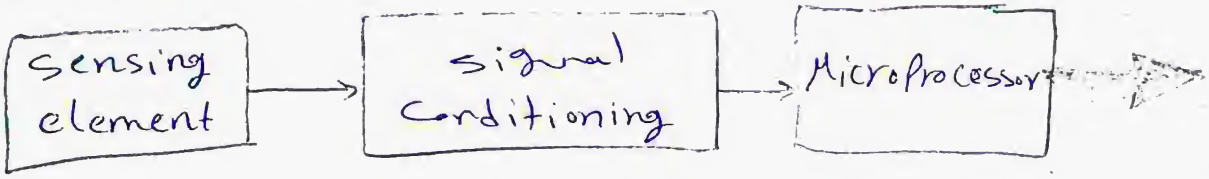
Q3.a

state with the aid of block diagrams the main difference between traditional integrated sensor and smart sensor.

1) Traditional integrated sensor



2) smart sensor



Q3.b) state the types of control systems that are used in the industrial control systems

~~1) ON-OFF Control~~

~~2) Open-loop~~

~~3) Closed-loop~~

~~4) Feed-forward~~

~~لم يتم ذكرها في المحاضرات (slides)~~

1) Programmable Logic Controllers (PLCs)
2) Distributed Control Systems (DCS)
3) SCADA Systems.

Q3.c) state yes or no.

i. A smart sensor which is called a system on chip has the ability to take decision as well as it consists of transduction element, signal conditioning electronic, and controller/processor (Yes)

ii) The Presence of a controller in smart sensor has led to corrections for different undesirable sensor characteristics which include span variation, non-linearity and cross-sensitivity (Yes)

3) The anatomy of SCADA system consists of elements of SCADA & levels of SCADA (Yes)

4) Data acquisition card (DAQ) is a PC card with analog and digital I/O interface that needs software ~~and~~ or user-generated code for its operation (Yes)

5) Transducers are devices that have no ability to change one form of energy to another (~~Yes~~) (No)

6) Transmitters are devices used to amplify and format signals so that they are suitable for transmission over long distances with zero or minimal loss of ~~the~~ information. (Yes)

7) Resolution is the largest amount of variable that an instrument can resolve, i.e., the largest change in a variable to which the instrument will respond (No)

Q3.d) state advantages of using SCADA systems in the industrial processes control.

1) Easy maintained (self diagnostic)

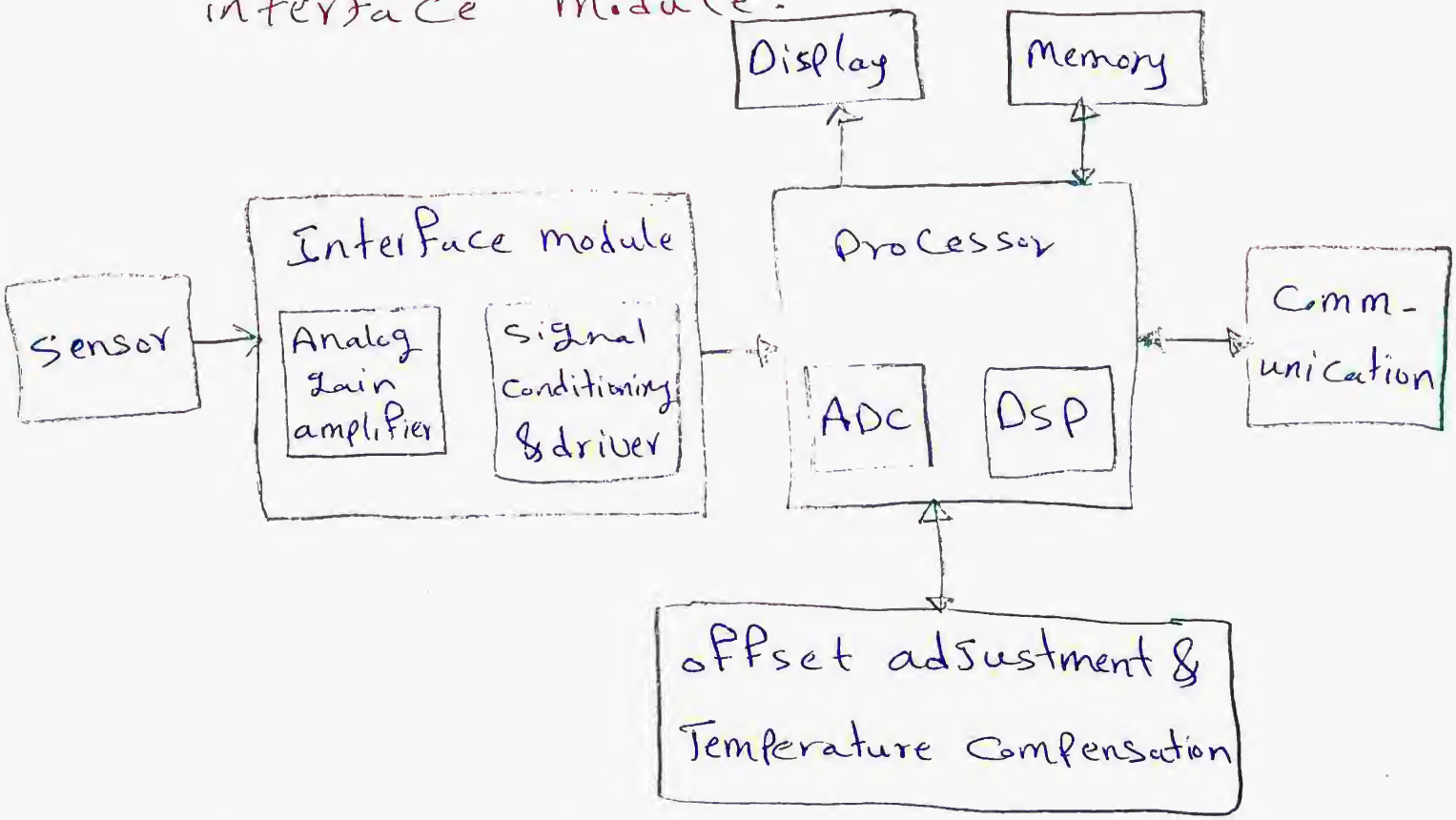
2) Capability to do arithmetic function.

3) Easily Programmed and reprogrammed.

4) ability to communicate with other controller or master host computer.

Q4-a

Draw a block diagram for components of smart sensor that contains both a network capable application processor and a transducer interface module.



Q4.b state advantages and disadvantages of using smart sensor.

[1] advantages

* High reliability.
* High performance.
* minimum cost.
* Scalable-flexible system.
* Easy to design, use and maintain.
* minimum interconnecting cables.

2. Disadvantages of smart sensors:-

* more complex than sensors (cause it consists of actuators and sensors)
* Complexity is much higher in the wired smart sensors => Costs are also higher.

Q4.c state the types of industrial networks and state their basic security elements that are needed to secure them.

Industrial networks:

- network of Programmable Controllers (PLC)
- Distributed Control Systems (DCS)
- Supervisory Control and data acquision (SCADA) systems.

security elements

- Confidentiality
- Integrity
- Availability.

Q4.d Yes or No

1) Network security measures used in SCADA system have authentication, authorization and accounting (AAA) as well as they have encryption of Data (Yes)

2) SCADA Components Consist of field instrumentation, a Communication network and Control Center (Yes)

3) Functions of SCADA system include only some of the following: Yes
Information display, supervisory control, Alarm Processing & tagging, Information storage & reports, Data calculation, and special RTU Processing Control

4) Most Key Priorities of control strategy appeared with SCADA are: Yes
* Balance Generation & demand (dispatching)
* Monitor Flows and observe system limits.
* Coordinate maintenance activities
* Protect equipment from damage.

5) The Preferred Power supply for SCADA systems is the alternating current (Ac) station system where these station systems can be inherently more reliable than direct current (Dc) (No)

6) SCADA systems are used in some processes applications such as higher education systems as well as information technology (IT) (Yes)

7) SCADA system depends only on remote terminal units (RTUs) collecting Field (No)

8) Actuators are devices that used to Control an input variable in response to a signal from a controller (Yes)

9) The advantages of having remote terminal units (RTUs) in the SCADA system is to transmit data and sending that data back to another RTUs via Communication system (Yes)